Teaching Algebra in an Online, Asynchronous Environment for the First Time: Insight from Mathematics Education Instructors

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Abstract:

Curriculum was designed to incorporate movement in a face-to-face algebraic reasoning course. However, the course was converted to an online, asynchronous format due to social distancing. The online course was taught by three mathematics education instructors in an upper division mathematics content course across eight different sections of the course (approximately 250 preservice K – 8 teachers). For all three instructors, this was the first time they taught an asynchronous online course. Results showed that there were some challenges the instructors faced. These challenges were primarily a result of preservice teachers' generally low comfort level in learning mathematics in an asynchronous environment. Modifications that had to be made to the curriculum will be discussed as well as suggestions for asynchronous mathematics content courses.

Introduction

When preparing elementary pre-service teachers for the mathematics classroom, it is imperative that instruction go beyond computation. As Greenberg and Walsh (2008) pointed out, mathematical preparation for pre-service teachers is often inadequate, and there needs to be a deeper focus on algebraic components that include equations and graphs. We designed a course to specifically address these inadequacies, by focusing on the use of movement as a context for graph development and interpretation. We planned to use motion detectors as well as an application that utilized the output of the motion detectors to create real-time graphs of both position and velocity as a function of time. Students could then explore the nature and behavior of the mathematical equations that best fit the automatically generated graphs. Our initial plan was to guide students in hands-on, in-class activities in which they would carry out certain movements and then observe and analyze the computer-generated graphs in real time. However, due to the COVID emergency, we were forced to make rapid and drastic modifications of our initial plan, converting the activities and the instruction to an asynchronous on-line format. This adaptation had to be done without first having had any opportunity to class-test the new movement-based curriculum in an in-person synchronous format.

To support the development of position/time and velocity/time graphs in this revised asynchronous format, an online application called "The Moving Man" was used. The simulation is available here:

https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man) or here: https://archive.cnx.org/specials/e2ca52af-8c6b-450e-ac2f-9300b38e8739/moving-man/

Through further adaptation of our original plan, we ultimately created a 5-week curriculum module that transformed how we taught the linear equation and graphing unit in the algebra course for preservice K-8 teachers. The course is based on both the state of Arizona's version of the Common Core State Standards (CCSSI, 2010) (a slightly modified version was adopted) as well as the guiding principles of the National Council of Teachers of Mathematics (NCTM, 2000). Our primary research question was the following: After transitioning algebraic content featuring movement into an online format for the first time, what obstacles were faced by the mathematics education instructors in relation to their preservice teachers' experiences? Our follow up research question was: What strategies did the mathematics education instructors employ to meet the preservice teachers' needs?

Methodology

Participants

There were three mathematics education instructors who participated in professional development, helped transition the curriculum to an asynchronous format, and provided feedback. All three instructors taught the curriculum during the Fall 2020 semester. We gathered data from these three instructors, whom we also trained to use the new curriculum. The mathematics education instructors had taught mathematics for 20, 22 and 29 years in higher education and public schools They were all former secondary teachers of mathematics in public schools. This was the first time they taught an asynchronous course (in any subject). Additionally, it was the first time some of their students had taken an asynchronous course in any capacity.

Data Collection

The transition to an asynchronous learning environment took place in the summer of 2020. During those summer months, the mathematics education instructors participated in converting all face-to-face curriculum to online. They created videos, curriculum, assessments, and other course material. The newly created course material was used during weeks 5 through 10 of the Fall 2020 semester. The curriculum was taught across eight sections of the course across three different campuses of a very large Research I university in the southwest United States. Data were gathered from the three mathematics education instructors immediately after implementing the unit in November 2020. We chose a focus group approach to rapidly capture summative feedback while the course was fresh in the instructors' minds and to create a setting where the instructors felt supported by each other (Krueger & Casey 2009; Patton 2002). To encourage openness and frank conversation, an experienced interviewer external to the curriculum design team conducted the focus group via the Zoom platform, drawing on best practices for online focus groups (Forrestal, D'Angelo, & Vogel 2015). The interviewer used a focus group guide developed with the research team and took detailed notes that were later deidentified. Data collection focused on answering these research questions:

- What challenges and limitations have emerged during implementation and what have been the responses to these?
- How well was the program implemented, for whom did it work well, and why did it work well for them?

Data were gathered to evaluate both the curriculum content and the curriculum format. Here, we present findings based solely on the curriculum format.

Data Analysis

The interview notes were reviewed line-by-line and labeled with key words by writing memos in the margins (Corbin & Strauss, 2008). Then, the data were coded using an open-coding technique. Codes were then compared and merged into new categories, which provided the basis for our interpretations. That is, throughout the process, grounded theory techniques (Glaser & Strauss, 1967) were applied, which involved iterative note reading, creating open coding, identifying common themes of three teacher educators' responses, categorizing their responses, and interpreting the data.

Results

The results are presented in relation to the online, asynchronous format. First, we present the obstacles the instructors faced. Then, we present adaptations they made to accommodate struggling students.

The curriculum design and instruction teams had to ascend a steep learning curve in how to design and teach an asynchronous, online course.

This course appears to be the first time that these instructors had taught an asynchronous, online course. In addition to learning how to make videos to post on Canvas, the instructors had to adapt to a different rhythm of teaching. They were unaware initially of how different this would be, and s/he feels that the course would have gone more smoothly from the outset if s/he could have given better information to the students to prepare them for online learning. "Week one had [students in] the most freaked out mode."

Many students were unhappy with the online, asynchronous mode of curriculum delivery.

All instructors noted students' initial resistance to the online, asynchronous format, and two of the instructors related that the majority of their students were unhappy with the course up to the end: "The majority really hated the online course," and "They [the students] did not like it at all ... I don't think any would [willingly] take the course." At the heart of these students' sentiments was that a required course, which was initially to be offered in-person, was changed to online, asynchronous delivery. Students noted that they "didn't sign up for an asynchronous course" and "don't do well online" (instructors quoting their students). Throughout the asynchronous instruction, students felt that the course left them "on their own" to learn the material, despite instructors' efforts to be in frequent contact with students, have students work in groups, and provide students with times to ask questions directly during online office hours.

Students who had fewer struggles with the class and the PEM curriculum tended to be those who managed time well, attended office hours, and worked in groups. Students coming into the class with higher mathematics skills from high school or college courses were also at an advantage.

The instructors noted that this online, asynchronous class format required students to manage their time well. They felt that much of the work could be completed during the originally scheduled class times but that many students decided not to dedicate this time to classwork. Students who worked in pairs and groups during the "class times" and other times appeared to experience fewer struggles and may have benefitted from peer-to-peer instruction and support.

Students who put off the class work until the last minute found that they did not allow enough time to watch the videos, understand the material, ask questions of their instructors, and complete the assignments or quizzes. Students who attended office hours or the optional synchronous instruction had fewer struggles. Students who had taken higher mathematics classes in high school and college were less likely to struggle with the class content as were those who had taken physics in either high school or college. These students had the mathematics skills to do well in this course regardless of course delivery format.

The asynchronous, online format may not have addressed the needs of students who are more anxious about mathematics, come into the class with relatively low mathematics skills, and need to ask questions during instruction.

The instructors noted that more anxious students with lower mathematics skills need confirmation that they are on the right track with their understanding of algebraic concepts through asking questions during instruction. The step-wise nature of solving problems means that an incomplete understanding of early steps puts the brakes on learning later steps. Students accustomed to asking questions during instruction now had to watch the video, allow for adequate time to ask their instructors questions, and then possibly watch the video again before completing assignments. At the same time, some of the students who were struggling did not avail themselves of Zoom meeting times with instructors or even the optional, synchronous instruction that one instructor offered later in the term. "The ones who complained, never came," stated one instructor.

Curriculum Adjustments/Observations made by the Instructors

It is important to note that although students struggled and were at times unhappy with the format, there was little impact on students' grades. At least one of the instructors affirmed that students' grades did not go down as a result of performance during the PEM curriculum unit; students ended up with grades very similar to those they had for work during prior (synchronous) weeks. The instructors made several adjustments to the curriculum in order to meet their students' needs as well as to create supportive structures that could help lead to success:

- Instructors convening "live," synchronous meetings/office hours provided support for those students who were organized enough and wise enough to take advantage of this opportunity.
- One instructor provided live demonstrations of the tools to students during virtual, synchronous class periods. Her/his demonstration of the movement aligned to graphs allowed students to direct her/his movements in real time while viewing the computer display placed within camera view, introducing an interactive element into the course. This demonstration clarified these class concepts for some students.
- Review videos for the summative assessment appeared to support students who took the time to prepare for the exam.
- Instructors commented that if the course was offered next semester as in-person class with an online synchronous option, they would have the students do the activities on camera and be at least partially responsible for explanations to online classmates.
- Instructors saw the value of the curriculum and noted that the tools and approaches to learning could support algebraic thought.
- Instructors felt well-prepared to teach asynchronously teach. Creating the curricular videos helped the instructors get comfortable with the content, although they tended to feel the most comfortable initially with the lessons they themselves created.

Discussion

Through necessity, we were forced to modify a new movement-based curriculum unit into a new format that was delivered completely online and predominantly in asynchronous mode. The consequent limitation of opportunities for rapid instructor-delivered feedback to support student learning led to some difficulties and dissatisfaction on the part of many of the enrolled students. Some opportunities for synchronous instruction were offered to the students, and those who took advantage of these opportunities had generally positive outcomes, reflecting the potential value of the curriculum. Going forward, if circumstances again require online delivery of the curriculum unit, increased opportunities for synchronous interaction will be integrated into course planning. In retrospect, our experiences with this forced change in delivery format reinforced our appreciation of the critical importance of rapid feedback in active-learning instruction, and of the necessity for maintaining some elements of such feedback whatever may be the course delivery method.

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